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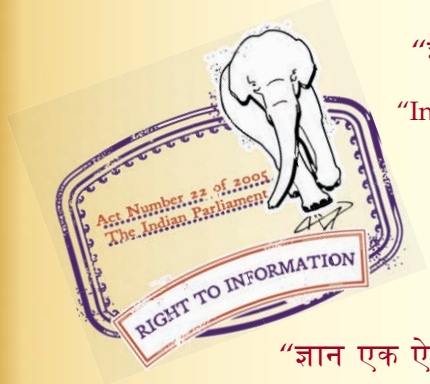
IS 10333 (1982): Epoxy resin systems for cast resin insulated power and control cable joints and terminations up to and including 11 kV [ETD 2: Solid Electrical Insulating Materials and Insulation Systems]



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"Knowledge is such a treasure which cannot be stolen"

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IS : 10333 - 1982

Indian Standard

(Reaffirmed 2004)

SPECIFICATION FOR EPOXY RESIN SYSTEMS FOR CAST RESIN INSULATED POWER AND CONTROL CABLE JOINTS AND TERMINATIONS UP TO AND INCLUDING 11 kV

UDC 621·315·616·96 : 621·315·68

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 5

June 1983

Indian Standard

SPECIFICATION FOR EPOXY RESIN SYSTEMS FOR CAST RESIN INSULATED POWER AND CONTROL CABLE JOINTS AND TERMINATIONS UP TO AND INCLUDING 11 kV

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Indian Standard

SPECIFICATION FOR EPOXY RESIN SYSTEMS FOR CAST RESIN INSULATED POWER AND CONTROL CABLE JOINTS AND TERMINATIONS UP TO AND INCLUDING 11 kV

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 20 October 1982, after the draft finalized by the Solid Electrical Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 Epoxy resins are finding increased use in the making of control and power cable joints and terminations on account of their simplicity of work and exceptional physical, chemical and electrical properties, such as dimensional stability, adhesion, chemical resistance and their thermo-setting nature. The manufacture of epoxy resins having been well established in this country, the need was felt for adopting uniform specification for these compounds. This standard has been prepared to meet this need.

0.3 This standard covers the requirements of epoxy resin systems for power and control cable joints and termination up to and including 11 kV, specification for epoxy resin system for 33 kV would be prepared at a later date when this type of resin would be developed in the country.

0.4 As the properties of the epoxy system depend on the composition of the mix, it is essential that the formulator should be consulted for material details and its usage and to their instructions or recommendations before use.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard covers two different types of epoxy resin systems for cast resin insulated power and control cable joints and terminations up to and including 11 kV rating.

NOTE — This standard is applicable to epoxy resin systems presently in use. It will be extended to the other casting resin systems such as polyurethane, acrylics when established in the country.

2. TYPE

2.1 Casting resin systems covered by this standard are classified as follows:

a) Type LV — suitable for cables rated for voltage up to and including 1·1 kV, and

b) Type HV — suitable for cables rated for voltage above 1·1 kV and up to and including 11 kV.

3. TERMINOLOGY

3.0 For the purpose of this standard, the following definitions shall apply.

3.1 Casting Resin — A liquid unfilled or filled which when mixed with hardner and/or catalyst sets to a solid mass.

3.2 Hardner — A substance which when mixed with casting resin converts the resin into solid mass.

3.3 Catalyst — A substance which when mixed with casting resin converts the resin into solid mass at an accelerated rate.

3.4 In addition to the above the definitions given in IS : 1885 (Part XXXII)-1971*, IS : 3434-1965† and IS : 4631-1968‡ shall apply.

4. COMPOSITION

4.1 The casting resin system shall essentially consist of:

a) Casting resin,

b) Hardner, and

c) Additive.

NOTE — Additives such as filler, pigment, foaming agent, plasticizer, etc, shall be added as agreed between the buyer and the manufacturer.

*Electrotechnical vocabulary: Part XXXII Cables, conductors and accessories for electricity supply.

†Glossary of terms for adhesives and pressures sensitive adhesive tapes.

‡Code of practice for laying of epoxy resin floor toppings.

5. GENERAL TEST CONDITIONS

5.1 Except when otherwise specified, all the tests shall be carried out at $27 \pm 2°C$ and a relative humidity of 65 ± 2 percent. The material shall be preconditioned under these atmospheric conditions at least for 16 hours prior to the testing.

6. GENERAL REQUIREMENTS

6.1 The consistency of casting resin and hardner and/or catalyst shall be as agreed to between the buyer and the seller and shall be within the tolerances as declared by the seller.

6.2 The casting resin, hardner and/or catalyst and other additives shall be mixed in a manner as prescribed by the seller.

7. REQUIREMENTS

7.0 Requirements of casting resin systems for power and control cable joints and terminations have been split up into two categories:

i) for the system as received and after it is mixed, and

ii) for the system after it has cured.

7.1 The properties of freshly mixed casting resin system shall be as given in Table 1.

TABLE 1 REQUIREMENTS OF FRESHLY MIXED CASTING RESIN

(*Clauses* 7.1 *and* 8.1.1)

Sl No.	Property	Test Method, Ref to Cl No.	Type LV	Type HV
(1)	(2)	(3)	(4)	(5)
i)	Mix viscosity	11.4.1	Not applicable	300 seconds (*Max*)
ii)	a) Maximum temperature	11.4.2	$\pm 10°C$ of the value recorded for the registered sample	
	b) Time to reach the maximum temperature	11.4.2	60 minutes (*Min*)	60 minutes (*Min*)
iii)	Gel time	11.4.3	45 minutes (*Min*)	90 minutes (*Min*)

7.2 Properties of the fully cured casting resin systems shall be as specified in Table 2.

TABLE 2 REQUIREMENTS OF CURED SYSTEM

(*Clauses* 7.2 *and* 8.1.2)

Sl No.	Property	Test Method, Ref to Cl No.	Requirements	
			Type LV	Type HV
(1)	(2)	(3)	(4)	(5)
i)	Compressive strength (*Min*)	11.4.4	5 N/mm^2	5 N/mm^2
ii)	Impact strength (unnotched) (*Min*)	11.4.5	5 kJ/m^2	5 kJ/m^2
iii)	Dimensional stability under heat by Martens method (*Min*)	11.4.6	Not applicable	45°C
iv)	Weight loss (*Max*)	11.4.7	2·5 percent	2·5 percent
v)	Water absorption (*Max*)	11.4.8	50 mg	50 mg
vi)	Dielectric strength (*Min*)			
	a) at 27°C	11.4.9	8 kV/mm	15 kV/mm
	b) at 80°C	11.4.9	8 kV/mm	15 kV/mm
vii)	Volume resistivity (*Min*)	11.4.10	1×10^{12} ohm cm	1×10^{12} ohm cm
viii)	Comparative tracking index (*Min*)	11.4.11	200 V	200 V
ix)	Dielectric dissipation factor (*Max*) at 70°C 50 Hz and 250 V	11.4.12	Not applicable	0·2
x)	Relative permittivity (*Max*) at 70°C, 50 Hz and 250 V	11.4.13	Not applicable	12
xi)	Thermal conductivity		Under consideration	

8. TESTS

8.1 Type Tests

8.1.1 *For Freshly Mixed System* — The test given in Table 1 shall constitute type tests.

8.1.2 *For Cured System* — The tests given in Table 2 shall constitute type tests.

8.2 Routine Tests

8.2.1 *For Freshly Mixed System* — The following tests shall constitute routine tests:

a) Mix viscosity,

b) Maximum temperature, and

c) Gel time.

NOTE — The routine tests are applicable to freshly mixed casting resin system only.

9. INSTRUCTIONS FOR USE

9.1 Supplier shall furnish information about method of use and precautions including storage conditions along with the supply. If necessary, the information may be furnished in the form of a published techninal literature.

10. PACKING AND MARKING

10.1 Packing — The individual components shall be packed in suitable containers as agreed to between the buyer and the seller.

10.2 Marking — Each container shall be indelibly marked with the following information:

a) Manufacturers' name or trade-mark or both,

b) Type of resin system,

c) Batch No.,

d) Quantity of material,

e) Date of packing, and

f) Date of expiry.

10.3 The containers may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

11. TEST METHODS

11.1 The form and dimensions of test specimens for various tests are given in Table 3.

TABLE 3 FORM AND DIMENSIONS OF TEST SPECIMENS

(*Clauses* 11.1, 11.2 *and* 11.4.6.2)

Sl No.	Requirements	Form and Dimensions
(1)	(2)	(3)
i)	Compressive strength	10 × 10 × 10 mm
ii)	Volume resistivity	150 ± 2 mm × 150 ± 2 mm × thickness not exceeding 3 mm
iii)	Dielectric Strength	
iv)	Dimensional stability under heat by Martens method	L = 120 ± 2 mm H = 15 ± 0·5 mm T = 10 ± 0·5 mm
v)	Impact strength	
vi)	Comparative tracking resistance	Disc
vii)	Water absorption	50 ± 1 mm diameter and
viii)	Weight loss	3 ± 0·1 mm thick

11.2 Preparation of Test Specimens — The epoxy resin cast specimens as per Table 3 shall be prepared from the components according to the details furnished by the supplier. The suppliers' recommendations shall be strictly followed with regard to mix quantities and temperature for mixing, curing (temperature and time), removal from the mould, annealing and cooling, as well as for machining the cast sheets.

NOTE — General curing for 16 hours at atmospheric conditions as per 5 and post curing for 4 to 6 hours at 80° C results in optimum properties.

Test specimens as per Table 3 above may also be provided by the supplier if it is so agreed between the supplier and the purchaser.

11.3 Conditioning of Test Specimens — All the test specimens shall be conditioned at least for 16 hours at standard atmospheric conditions prior to testing as per 5 of this standard.

11.4 Details of Test Methods

11.4.1 *Mix Viscosity*

11.4.1.1 *Outline of the method* — All the components are mixed according to the details furnished by the supplier and the mixed material is

tested for its efflux time by a flow cup immediately. The average value of three values is reported.

11.4.1.2 *Procedure* — The consistency of mixed material is determined by flow cup No. 6 of IS : 3944-1966* at 27 ± 0·5°C with a relative humidity of 45 to 75 percent as per **7.4.1** of IS : 101-1964† and efflux time is noted. The average value of the three values shall be reported as the mix viscosity.

11.4.2 *Rise in Temperature and Time to Reach the Maximum Temperature*

11.4.2.1 *Outline of the test procedure* — It consists of determination of the maximum temperature in the middle of the specimen and the time required to reach the maximum temperature during hardening of epoxy resins.

11.4.2.2 *Test apparatus*

a) Long necked round bottomed 250 ml flasks made from heat resistant glass;

b) Liquid bath with thermometer for measuring temperature ± 0·5°C, fixed with thermostat and circulating pump or stirring appliance;

c) Temperature measuring apparatus for temperatures up to 200°C with scale divisions of 2°C;

d) Balance with an accuracy of ± 0·01 g; and

e) Stopwatch.

11.4.2.3 *Procedure* — Weigh components to make a mixture of about 250 ml to an accuracy of ± 0·5 percent into separate vessels and condition at 27 ± 2°C. Add the components to each other and start measuring time. Mix the components by stirring for five minutes. Fill the round bottom flask with 200 ml of mixture. Fix thermometer or thermocouple in the middle of the reaction resin moulding material. Place the flask in a liquid bath which is at 27 ± 0·5°C. The surface of the reaction resin moulding material shall be below 10 mm of the liquid level. Record the rise in temperature with respect to time under the controlled conditions and report the maximum temperature attained and the time in minutes required to reach the maximum temperature.

11.4.3 *Gel Time*

11.4.3.1 *Outline of the test procedure* — Gel time shall be regarded as the period of time between the start of the testing and the point at which the reaction resin moulding material changes from liquid to a gelled state.

*Specification for flow cups.

†Methods of test for ready mixed paints and enamels (*second revision*).

11.4.3.2 *Test apparatus*

a) Thermostat in which the temperature can be adjusted up to 100°C and on which the temperature set can be maintained constantly to an accuracy of ± 0·5°C,

b) Test tube of 20 ± 2 mm dia with wall thickness 0·45 ± 0·2 mm and height 150 mm,

c) Glass rod of 2 mm diameter with thickened end of about 6 mm dia,

d) Balance with an accuracy of ± 0·001 g, and

e) Stopwatch.

11.4.3.3 *Procedure* — Condition the components individually to 27 ± 2°C. Mix the components and after 5 minutes the test mixture shall be poured into the test tube to a height of 40 ± 2 mm. Introduce glass rod and close test tube with a stopper containing a hole for glass rod. Place test assembly afterwards in the liquid bath with thermostat adjusted to the testing temperature of 27 ± 0·5°C, in such a way that the level of the test mixture is below the surface of the thermostat liquid and the test tube hangs in the holder so that it can be moved.

The stop-watch shall then be started. Not more than 60 seconds should elapse between preparing the test mixture and starting the stop-watch. The gel time is determined by raising the glass rod slightly at the intervals of 15 seconds. As soon as the test tube can also be lifted with the rod, because the reaction resin moulding material has gelled, the time that has elapsed from the beginning of the test until this point shall be recorded as the gel time.

11.4.4 *Compressive Strength* — This test shall be carried out as per **8** of IS : 1998-1962* on five specimens prepared as per **11.2** and conditioned as per **11.3**.

11.4.5 *Impact Strength* — This test shall be carried out as per **9** of IS : 1998-1962* on five specimens prepared as per **11.2** and conditioned as per **11.3**.

11.4.6 *Dimensional Stability Under Heat by Martens Method*

11.4.6.1 *Outline of the method* — Dimensional stability under heat by Martens method is the ability of a test specimen largely to preserve its shape under a given static bending stress up to a certain temperature. It is characterized by the temperature at which the increasingly heated specimen is deflected by a given amount underload.

*Methods of test for thermosetting synthetic resin bonded laminated sheets.

11.4.6.2 *Test bar* — For the purpose of this test, the test specimen shall be prepared as per the procedure given in **11.2**. The dimension of the test specimen shall be as given in Table 3.

11.4.6.3 *Test apparatus*

a) Length measuring scale and calipers,

b) Calibrated fine-reading thermometers from 0 to 250°C graduated at an interval of 1°C,

c) *Gripping and indicating device* — To permit the test specimen clamped in a position in the manner shown in Fig. 1. An indicating device shall show when the end of the lever arm has sunk to the prescribed extent as a result of deflection of the loaded specimen.

NOTE 1 — For convenience, calculations involved in designing the test apparatus are given in Appendix A.

NOTE 2 — Details of upper clamping head for gripping device are shown in Fig. 2. The lower clamping head is designed accordingly.

d) Heating oven with temperature regulating device to raise the temperature at the rate of 50 ± 1°C per hour from 27 ± 2°C to 250°C. The oven shall provide an even temperature of ± 1°C every where in the vicinity of test specimen. It shall be possible to measure the temperature at the side on the upper end of the first specimen and at the side in the lower end of the third specimen.

e) Light and sound signalling device wherever necessary. It shall be an electrical signalling appliance which indicate when a lever arm has sunk to the prescribed extent one light signal for each test specimen and joint sound signal for all test specimens.

11.4.6.4 *Procedure* — Measure the cross section dimensions of the test specimen to an accuracy of 0·1 mm in the middle of the test specimen. The test bar shall be held in a clamp in a vertical position in the apparatus. It shall be subjected to constant bending stress of 5 MPa by means of the loaded arm, the load shall be calculated as given in Appendix A. The lever arm shall be horizontal. Set the indicating appliance in such a way that it is possible to record the sinking of the loading lever by 6 ± 0·1 mm.

The apparatus shall be placed in the heating oven and the temperature raised at a constant rate of 50 ± 1°C per hour.

The temperature at which the lever falls through a height of 6 ± 0·1 mm or at which the specimen breaks whichever is earlier shall be noted.

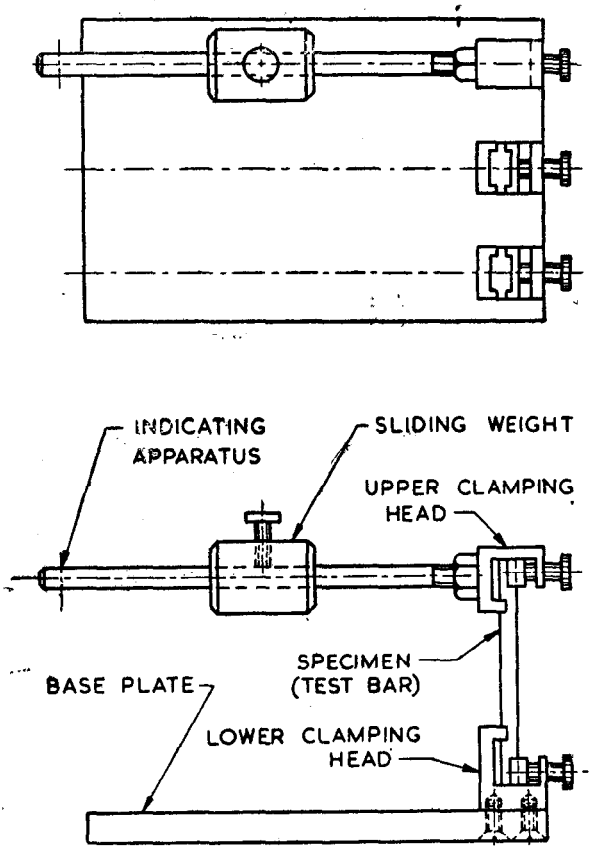
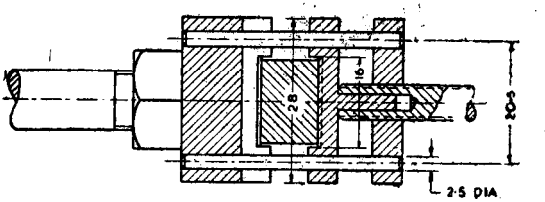


FIG. 1 APPARATUS FOR SOFTENING POINT TEST

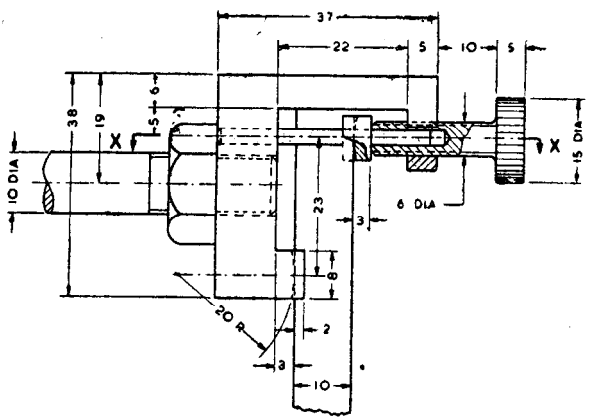
During the test the temperature shall be measured at the side on the upper end of the first specimen and at the side on the lower end of the last specimen. The mean temperature from the readings of the two temperature measuring points at which the lever falls through a height of $6 \pm 0{\cdot}1$ mm or at which the specimen breaks whichever is earlier shall be the dimensional stability under heat by Martens method.

If the temperature of the two thermometers deviate from each other during the test by more than 2°C or if there is external evidence of damage on the test specimens, the tests results shall be discarded and the test shall be repeated.

In the case of tests carried out in succession the heating oven shall be cooled down to 27 ± 2°C before introducing new test specimen.



SECTION XX



All dimensions in millimetres.

FIG. 2 CLAMPING ARRANGEMENT

11.4.7 *Weight Loss*

11.4.7.1 *Outline of the method* — Cured specimens prepared as given in **11.2** are weighed accurately and aged in an oven at 140°C for 168 hours. Later on they are cooled, conditioned and reweighed.

11.4.7.2 *Test apparatus*

a) Balance with an accuracy of ± 0·001 g, and

b) An electrically heated oven with an accuracy of ± 2°C.

11.4.7.3 *Procedure* — Prepare three specimens as mentioned in **11.2**. Condition the specimens as given in **11.3** and weigh to the nearest milligram on the balance. Suspend the specimens in an electrically heated oven maintained at 140 ± 2°C for a period of 168 hours.

After ageing, remove the specimens from the oven and cool to atmospheric condition. Weigh the specimens to the nearest milligram on the balance. Calculate the percentage weight loss by the following equation and report the average of three values:

$$\text{Weight loss percent} = \frac{w_1 - w_2}{w_1} \times 100$$

where

w_1 = initial weight of the specimen after conditioning, and

w_2 = final weight of the specimen after ageing and cooling to atmospheric condition.

11.4.8 *Water Absorption*

11.4.8.1 *Outline of the method* — Cured specimens prepared as given in **11.2** are immersed in distilled water for 24 hours at standard atmospheric conditions after accurate weighing. On removal from water, they are wiped dry with blotting paper and reweighed.

11.4.8.2 *Procedure* — Prepare five specimens as given in **11.2**. Condition the specimen as given in **11.3** and weigh to the nearest milligram on a balance with an accuracy of 0·1 mg. Immerse the specimen completely into distilled water for a period of 24 ± 1 hours at a temperature 27 ± 2°C. On removal from water, quickly wipe dry the exposed surface of the specimens with blotting paper or clean cloth. Reweigh the specimens to the nearest milligram and complete the weighing with two minutes of the removal of the specimen from water. Record the increase in weight in milligram. The average value of the five values shall be reported.

11.4.9 *Dielectric Strength* — Dielectric strength shall be determined by rapidly rising method as described in **7** of IS : 2584-1963*.

11.4.10 *Volume Resistivity* — Volume resistivity shall be determined as per IS : 3396-1965†.

*Method of test for electric strength of solid insulating materials at power frequencies.

†Methods of test for volume and surface resistivities of electrical insulating materials.

11.4.11 *Comparative Tracking Index*

11.4.11.1 *Outline of the method* — This method indicates the susceptibility of cured resin surface to tracking when exposed, under electric stress, to an electrolyte. The principles of the test are as described in IS : 2824-1975*.

11.4.11.2 *Test apparatus* — The test apparatus is the same as described in IS : 2824-1975*.

11.4.11.3 *Procedure* — Prepare five specimens as mentioned in **11.2.** Test each specimen at different voltage to permit the construction of a curve showing the number of drops required to cause breakdown as a function of voltage. Each separate test shall be made on a fresh part of the surface or on an unused specimen.

From the curve thus obtained, the value of the comparative tracking index is derived by reading of the voltage corresponding to 50 drops on the horizontal (rms voltage) axis.

11.4.12 *Dissipation Factor at* 70°*C*, 50 *Hz*, 250*V* — Dissipation factor shall be determined as per IS : 4486-1967† at 70°C. This test is applicable only for type HV.

11.4.13 *Permittivity at* 70°*C*, 50 *Hz*, 250*V* — Permittivity shall be determined as per IS : 4486-1967† at 70°C. This test is applicable only for type HV.

12. SAMPLING AND CRITERIA FOR CONFORMITY

12.1 Sampling and criteria for conformity shall be subject to agreement between the supplier and the purchaser.

*Method for determining comparative tracking index of solid insulating materials under moist conditions (*first revision*).

†Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power audio and radio frequencies including metre wavelengths.

APPENDIX A

(*Clauses* 11.4.6.3 *and* 11.4.6.4)

CALCULATIONS RELATING TO MARTENS TEST

A-1. Let the specimen be held in a vertical position by means of two clamping heads, the upper clamping head carrying a lever arm with sliding weight, as in the actual apparatus.

A-1.1 The bending moment to which the specimen is subjected is given by the equation:

$$M = W_s L_s + W_l L_l + W_p P_p$$

where

M = bending moment in $N.m$,

W_s = load in N of the sliding weight,

L_s = distance in m of the centre of gravity of the sliding weight from the longitudinal axis of the sample,

W_l = load in N of the lever arm and of the upper clamping head together with its support,

L_l = distance in m of the centre of gravity of the lever arm including the upper clamping head from the longitudinal axis of the sample,

W_p = load in N of the indicating pointer, and

L_p = distance in m of the longitudinal axis of the indicator pointer from the specimen.

A-2. Representation of bending moments is shown in Fig. 3. The bending moment over the length B corresponds to the moment P_{xa} (that is, $M = P_{xa}$) and within certain limits of the length of specimen the bending moment is independent of the length B. With too large a value of B, significant errors may arise during the lowering of the lever arm together with the weight through the lateral deflection of the specimen. The selection of the length of the sample is, therefore, important and, for the apparatus described in **11.4.6.3** with the clamping arrangements shown in Fig. 3, a length of 120 mm, a width of 15 mm and a thickness of 10 mm are found to be suitable.

A-3. The length L_s shall also be sufficiently great for a relatively small weight W_s so that the compressive force which W_s produces on the

clamped specimen is negligible. A mass of 650 g is found to be suitable. If the length L_s is desired, it can be calculated from the following:

$$\frac{\text{Bending moment } (M)}{\text{Modulus of section } (z)} = \text{Bending stress} \quad \ldots \quad (1)$$

A bending stress of 5 *MPa* is prescribed for plastic materials for this test, that is

$$\frac{M}{z} = 5 \ MPa \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

The modulus of section of the specimen $z = \frac{bh^2}{6} m^3$ ... (3)

where

b is the width of the specimen and h its thickness in metres. From equations (2) and (3)

$$M = \frac{5bh^2}{6} \times 10^6 \ N.m \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

and from (1) and (4)

$$W_s L_s + W_l L_l + W_p L_p = \frac{5bh^2}{6} \times 10^6 \quad \ldots \quad \ldots \quad (5)$$

$$L_s = \frac{5bh^2}{6W_s} \times 10^6 \quad \frac{(W_l L_l + W_p L_p)}{W_s} \quad \ldots \quad \ldots \quad (6)$$

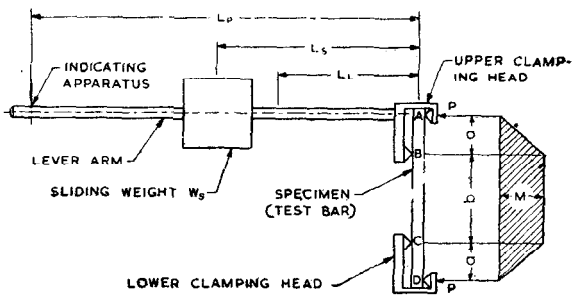


FIG. 3 DIAGRAM SHOWING CALCULATIONS OF BENDING MOMENT